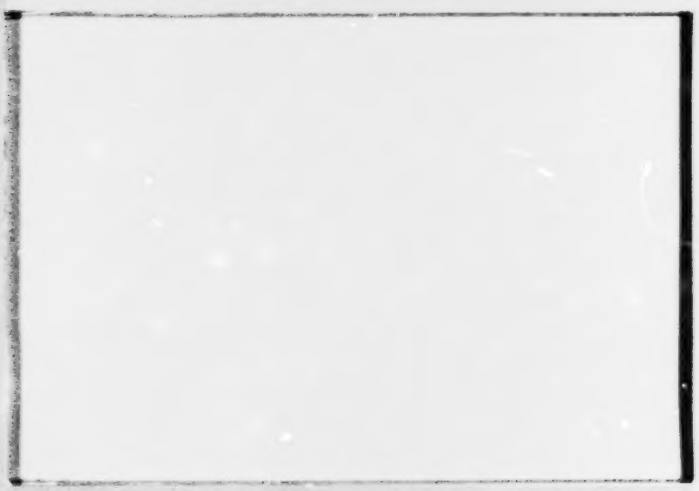
N.W.T. 18

Canada/Northwest Territories Conservation and Renewable Energy Demonstration Program



Energy, Mines and Resources Canada

Energie, Mines et Ressources Canada

Northwest Territories Public Works

FORT PROVIDENCE
WASTE HEAT
RECOVERY

Prepared By

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NORTHWEST TERRITORIES/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of N.W.T. and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed March 24, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Cost-shared by the territorial and federal governments, the program has a total budget of $3.3 million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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1.0

SYNOPSIS

1.0 SYNOPSIS

This report was commissioned by CREDA to provide the results of the experience gained and guidance for the replication of a unique energy supply and conservation system in Fort Providence, N.W.T. Savings of $2,500 per month were realized on a total capital outlay of $50,000 (not including the considerable time spent by the owner). To achieve this pay-back in less than two years the owner designed the entire system himself and, over a ten year period, has developed one of the most advanced diesel generator/heat recovery/district heating/radiant floor energy efficient building systems in existence.

The owner successfully applied to CREDA in 1980 to further enhance this sophisticated yet reliable operation by the addition of a wood waste gasifier to fuel a diesel generator. The experience of this project is reported separately (CREDA NWT Project #1).

1.0 SOMMAIRE

Ce rapport a été compilé sur la demande de CREDA afin de faire connaître l'expérience acquise et d'offrir une direction pour la répétition de cette source unique d'énergie et du système de conservation de Fort Providence T.N.O. qui a realisé des épargnes se chiffrant a $2,500 par mois sur un investissement de $50,000 (ce qui n'inclu pas les heures considérables de travail fournies par le propriétaire). Afin de réaliser cette épargne en moins de deux ans, le propriétaire a du développer les systèmes lui-même et durant une période totalle de dix ans, il a developpé un système de générateurs diesel, un système de récuperation de chaleur résiduaire, chauffage régional et un système de plancher rayonnant des plus efficaces en energie présentement en existence.

En 1980, le propriétaire demandait de l'assistance de CREDA afin de pouvoir continuer ce developpement et y ajouter un gasogene a bois le gaz duquel deviendrait le carburant pour l'operation du générateur diesel. Cette expérience apparait sous un différent rapport (CREDA NWT Projet #1).

2.0

FORT PROVIDENCE BACKGROUND INFORMATION

2.0 FORT PROVIDENCE: BACKGROUND INFORMATION

Fort Providence is situated 233 air km. S.W. of Yellowknife, N.W.T., on the north bank of the Mackenzie River. With a population of approximately 500, it is typical of many of the communities spread across Northern Canada.

The annual temperatures in the region range from a mean July high of 23.1° C, down to a mean January low of -31.2° C.

The present site for the community was established by a Roman Catholic Mission in 1861. At one time agriculture was an important feature of life and it has always been a traditional trapping community. The construction of a highway to Yellowknife, giving road access to many of the Northern communities was an important event. A ferry crossing over the Mackenzie created some employment and the local Dene band encouraged the establishment of a fibreglass plant to provide more job opportunities.

The major economic activities include tourism, the area being well known for its good fishing; highway rest-stop; trapping; Dene handicrafts and fire fighting of the large surrounding wooded areas.

Infrastructure

Power: Power for the community is provided by Alberta Power Limited. 1982-83 rates for general consumers: demand charge $3.05/KW of billing demand, energy charge: 1st 200 kWh 27.28¢/kWh, next 200 kWh 24.00¢/kWh, over 400 kWh/kW of billing demand, 22.47¢/kWh; fuel clause adjustment rider 3.784¢/kWh.

Water: The source is the Mackenzie River, with a piped and trucked delivery system.

Sanitation: All residences have sewage pump-out, the sewage being deposited into a series of lagoons beside the 'dump', 3 km from the settlement.

Transportation:
Air: Licensed gravel/sand, unlit runway.
Road: Mackenzie Highway system, N.W.T. No. 3; 5 km access road.
Water: Ferry Service at Mackenzie River crossing.

Electricité:

L'electricité de la communauté est fournie par la compagnie Alberta Power Limited. Les taux chargés pour consommation domestique en 1982 83 furent: sur demande $3.05/kw de facturation, la charge pour l'énergie: les 1er 200 kwh 27.28 sous/kwh, les 200 kwh suivants 24.00 sous/kwh et les usages excédant 400 kwh/kw de la demande de facturation, 22.47 sous/kwh; la clause d'ajustement pour le carburant est de 3.784 sous/kwh.

Eau:

L'eau potable provient du fleuve Mackenzie. Il y a un système de tuyauterie en existence mais cette eau est aussi livrée par des camions citernes.

Système d'Egoûts:

Chaque résident fait pomper ses égoûts les déchets étant disposés dans des étangs situés près du depotoir municipal situé a 3 km de la communauté.

Transportation:

Air: piste d'atterissage de gravier et sable, licensiée ayant des pistes non-illuminées.
Chemin: route Mackenzie T.N.O. #3; 5 km de route d'acces.
Eau: traversier sur le Mackenzie.

2.0 FORT PROVIDENCE: INFORMATION GENERALLE

Fort Providence est situé a 233 km au sud-ouest de Yellowknife T.N.O., sur la rive nord du fleuve Mackenzie. Ayant une population d'environ 500 habitants, cette communauté ressemble à beaucoup d'autres que l'on rencontre a travers le grand nord canadien.

Les températures annuelles de la région se maintiennent entre des hauts de 23.1 degrés celsius en juillet et des bas de -31.2 degrés celsius en janvier.

Le site actuel de la communauté fut colonisé par des missionaires catholiques en 1861. L'agriculture fut antérieurement très importante dans la vie quotidienne des résidents et la traite de la fourrure est restée traditionellement un de ses intérêts principaux. La construction d'un chemin reliant Yellowknnife à plusieurs autres communautés nordiques fut un évenement de grande importance. La mise en place d'un traversier reliant les deux rives du Mackenzie créa des emplois et la bande Dene encouragea L'établissement d'une manufacture de fibre de verre laquelle créa d'autres opportunités de travail.

Les activités économiques les plus importantes inclues le tourisme, la région étant reconnue pour son excellente pêche; ses sites de repos sur la grand route; la traite de la fourrure; l'artisanat Dene et le combat du feu dans leurs gigantesques

3.0

DEVELOPMENT OF SNOWSHOE INN LTD.

3.0 DEVELOPMENT OF SNOWSHOE INN LIMITED

The original coffee shop, which stands today, was built in 1965, filling a long overdue need of the community. In the following 5 years the "Snowshoe Inn Limited" developed. The building area of the facility rose from the initial 33 sq. m. coffee shop, up to a gross building area of 743 sq. m., including a restaurant, dining room, cocktail bar and handicraft shop. All of the additional building areas were heated with a propane-fired furnace system, which was expanded as the new heating needs arose.

The old motel was built in 1970 and its 371 sq. m. area was built up by a 186. sq. m. permanent structure and 371 sq. m. of trailer units. The total building area on the site had now increased to 1,300 sq. m., with all the heating being provided by propane furnaces.

In 1971, discussions were in progress concerning the possibility of expanding the temporary motel space into a larger permanent structure and of building a new warehouse to the north of the site. It was proposed that the new motel area would be 1,672 sq. m. and that of the warehouse 557 sq. m. These additional areas would mean more than doubling the existing building area on the site and so it was clear why the manager was very careful in his calculations for the increased power and heating costs that would be incurred. He explored the possibility of obtaining reduced power rates but both parties realized that the reductions would have to be too substantial to make the new building program viable.

After much thought, the manager decided to install two generators in what would be the new warehouse.

In 1973, the construction of a motel began, with completion in 1974. The generators were put into place in the Summer of 1973.

3.1 Development of the Heating Distribution System

During the period 1965-1973, all the buildings were self-contained with their own propane-fired heating systems. It was not until the decision had been made to install the generators, thus creating a single heating source, that a need arose for a distribution system.

The pipes could either be installed above or below the ground but the only section where the pipes had to be underground was where they crossed the road to the motel.

The first installation (see Figure 1) consisted of two 38 mm polyethylene pipes. These pipes were installed in 1973 and ran at ground level with a fibreglass insulation blanket and protecting polyethene wrap-around sheet. The pipes were buried where they crossed the road.

Right from the start there was concern that the buried portion of the pipes was susceptible to damage due to the ground movement in winter. In fact a split developed in the first winter and as it could be seen that this was not the best way to run the pipes, other ideas were considered.

In preparation for the next heating season, a wooden utilidor box (see Photo P-7) was constructed in which two new polyethylene pipes could run. The box ran from the warehouse to the motel, with a branch leading off to the restaurant complex. The dimensions of the box were 250 by 250 mm. On the inner faces were slabs of 25 mm thick polystyrene insulation and packed around the pipes themselves was loose zonalite insulation. This system proved to be very successful and remained in place for 8 years, until 1982. One drawback was the fact that, as in the previous system, the utilidor had to be buried where it crossed the road. This meant that it was inaccessible and any problems that may have developed during the heating season would have caused an unacceptable interruption to the heating service. When the pipes were finally replaced, they actually were pulled from the utilidor, although it took a large number of men to accomplish the feat.

The major fault of the polyethylene pipes themselves, was not found until a few years after initial installation. The pipes developed radial cracks at the joints which ultimately started to leak and this was the reason why it was decided to replace them in 1982.

In 1982, a substantial improvement was made to the distribution system. A 1,000 mm diameter galvanized steel culvert was used as an oversize utilidor, running underground from the warehouse to the restaurant and then from the coffee shop to the motel (see Figure 2). Within this culvert were the two hot water pipes carrying the waste heat from the diesel engines to the various building heating systems. The cold water pipe follows the same route. Excess warm air from the generator room is blown through the culvert which maintains the air temperature inside well above freezing and also keeps the pipes' heat loss to an absolute minimum. The pipes are not insulated and temperature readings of the water taken at inlet and outlet of the culvert do not differ.

Another important change in 1982 was the change in pipe material. From 1965, polyethylene pipe had always been used to transport the hot water. It was found to be excellent pipe giving few problems but as mentioned, the problem of the radial cracks at the joints developed. The Motel Manager, with many close contacts in Europe, had personally seen the success of polybutylene pipe used in many different applications. In Europe this type of pipe has been used for many years, mainly for slab heating and plumbing systems, but also in other areas. This pipe was felt to be the most suitable for the application required at Fort Providence and so the two 50 mm hot water distribution pipes are now polybutylene. The research and study of the material and its applications have been put to good use in this case and Appendix 1 outlines some of the overall qualities of the material.

4.0

DIESEL POWERED GENERATOR SYSTEM

4.0 DIESEL POWERED GENERATOR SYSTEM

Equipment

These are three generators. #1 and #2 were installed in 1973. #3 was installed at a later date to provide the extra stand-by capacity.

#1: Tamper generator, Canron Limited: 75 kW capacity
Powered by 4-71 in-line, naturally aspirated, GM diesel engine.

#2: Tamper generator: Canron Limited: 100 kW capacity
Powered by 6-71 in-line, naturally aspirated, GM diesel engine.

#3: Brown Boveri: 175 kW capacity
Powered by 6-71, in-line, turbo-charged, GM diesel engine.

4.1 Waste Heat Recovery

The generators have two functions:

1. To provide the electrical power for the site.
2. To provide the heating for the site, which is given off by the diesel engines.

The energy input into the generators can approximately be broken down as follows:

1. 35% is converted into Brake Horse Power and used as electrical power.
2. 25% is given up as heat to the circulating jacket water.
3. 4% is given up as heat to the lubricating oil.
4. 36% is given up as heat contained in the exhaust gas.

In order to make the generators perform efficiently, as much as possible of this waste heat must be reused. During the winter months this efficiency is high, as there is a large demand for the waste heat.

4.2 Jacket Water Circulation

The generator's jacket water is not separate from the main heating system. The jacket water leaves the diesel engines at approximately 80° C and enters a small buffer tank at the top. This water is mixed with water returning from the motel and other heating systems. The jacket water returns to the engine from a connection at the base of the tank, the water generally having cooled to approximately 27° C. The engine pumps are therefore used only to pump through the engines, and then to and from the buffer tank.

The main system flow and head is handled by a single pump positioned in the generator room. The pump is a Bell & Gossett, 4 L/S at 36 kPa head, 1/2 HP motor. It is intended that a standby pump be installed in the future.

From the buffer tank the water is pumped into an exhaust heat exchanger room and from here the route taken by the water is determined by the heat requirements of the system. As shown on figure 3, isolating valves are installed on all branches so a particular section of the system can be bypassed if not required.

The jacket water can be redirected straight back to the hotel/restaurant system if heat requirements are low. As requirements increase the water passes through the exhaust heat exchanger. This exchanger is actually an old cast iron boiler. The hot flue gases pass into its base and heat up the circulating water in the water passages. This provides a high grade heat. It is usually only necessary to adjust the flow to the exhaust heat exchanger twice a year. In the spring, the exchanger is bypassed by the heating water and the flue damper opens to allow the flue gases from the diesel engines to pass straight to atmosphere. In the fall, as the motel demand for the heat increases, the heating water is diverted through the exchanger, in order to transfer as much waste heat as possible from the gases. The flue damper is closed and the excess heat in the gas used for further heating (see below).

When the water coming from the exhaust heat exchanger is too hot it is directed up into a 18,000 litre storage/surge tank. This tank becomes a huge hot water reservoir and it helps to keep the system temperature as constant as possible. It is hoped to connect the heating system to the nearby swimming pool in future and this large storage tank would be particularly useful then.

The heating system is an 'open' system operating at a pressure of approximately 75 kPa (11 p.s.i.). This pressure is created by the static head of this large storage tank. A 200 litre header tank sits on top, to which the cold water supply is connected, maintaining the system capacity.

Much of the system is completely manual. The many valved circuits can be set manually according to the conditions in the buildings and that of the jacket water. The system is checked at least twice every day, and as there is a maintenance engineer permanently on staff, the balance of the system can be constantly adjusted.

4.3 Exhaust Gas

The exhaust gas is an important source of waste heat and at the Snowshoe Inn, almost 100% of that heat is utilized.

The bulk of the heat is taken out by the circulating water. The remaining heat in the flue gas, rather than being exhausted straight to the outside as is the usual case, is transferred to the research area. (In summer when heating is not required the flue gas is discharged straight to outside).

When fully loaded, the engines' flue gas temperature is approximately 500° C. By the time it has passed through the exhaust heat exchanger, the temperature has dropped to approximately 100° C. This low temperature is much lower than is usually recommended, but the corrosive conditions that are created at these low temperatures are allowed for in this system.

As shown in Figure 5, from the heat exchanger the flue drops into the floor slab of the research area. Branches of the steel duct, set in the concrete floor, radiate out through the building, providing the total heating.

An exhaust fan draws the gases through the floor and discharges them at high level. The condensation formed in the ducts, drains down into a sump from where it is periodically pumped out.

The majority of fires in generating plant buildings are associated with the tremendous heat output of the engine exhaust manifold. In order to lessen the risks involved, the engines were ordered with a special marine modification. The returning jacket water passes into a water jacket incorporated around the exhaust manifold. Primarily this action cools down the manifold but an important side-effect in this case is that it also heats up the returning water. The lowest recommended water temperature to the engine is approximately 40° C. The temperature in this case is 30° C and so the exhaust gases help to heat this so that there is not such a shock to the engine.

5.0

SNOWSHOE INN HEATING SYSTEMS

5.0 THE SNOWSHOE INN HEATING SYSTEMS

Each building has its own particular characteristics and each of the heating systems is different in one form or another.

The Heating Medium

The heating medium is the same water that is circulated through the engines, the exhaust heat exchanger and then transported underground to each of the individual buildings.

There is no glycol in the hot water which may surprise many people, particularly when even today the distribution pipes to the two residences still run overground (see Photograph P-13). For the years 1973-1982 all the distribution pipes were run above ground, but in that whole time there were no major freeze-ups.

The reason why glycol had never been added to the system was purely one of expense. The total system water capacity is approximately 21,400 litres. At a 50% water/glycol concentration and a glycol price in the range of $.16 per litre, the cost of the mixture would approach $17,200.00. In retrospect, this is a high price to pay for a service that would not have been required. As can be seen in the development of the piping system however, the dangers of freezing have not been overlooked and the pipes now run in their own heated shaft.

Although glycol has never been added to the water, a chemical compound is mixed with the water to maintain pH8-10. This helps to keep the systems clean and inhibit corrosion which is particularly important in the steel floor slab heating pipes.

5.1 New Motel

This building was designed with the knowledge that low grade waste heat would be available for heating purposes, from the newly installed generators. The building is of a steel frame construction, with three floors including a basement. There is a concrete floor at each level.

As the waste heat water temperature can fall down to 32° C, the only practical alternatives for a heating system are a warm air system or a slab heating system. In fact both types of systems are used in the building.

The 50 mm polybutylene hot water pipes enter the motel at basement level, emerging from the culvert into the mechanical room (see Photograph P-8). These pipes then provide hot water for the slab heating system, the two make-up air units and the domestic hot water heat exchangers before running to the office and residence (see Figure 4).

Heating and Ventilation Systems

The slab heating system is within the basement slab only. It is comprised of a single circuit, with a total length of piping in the slab of 1,875 m. 25 mm polyethylene pipe was used. During the laying process the pipe must not be kinked in any way. If this does happen, the pipe loses its strength dramatically and the combination of heating and an increase in pressure to only 6 p.s.i. can cause leaking. A leak was in fact made in this way, and the pipe had to be pulled out an repaired. The pipe was laid so that the hottest water flowed at the cold, river side of the motel. The heating on the opposite side of the motel, however, where the hot water had dropped from approximately 38° C to 21° C, was still satisfactory.

Additional heating is provided to the public areas of the Motel. At each of the 3 levels, warm air is discharged, providing the make-up air for all the bathroom fan units. It also creates a positive pressure in the lobby and corridors, minimizing the uncontrolled air infiltration.

Even though the slab heating was installed only in the basement slab, very little temperature difference can be felt between the rooms on the 3 floors. Due to the high thermal inertia of the slab, the hot water temperature is kept low enough to maintain an air temperature of approximately 15° C in the motel bedrooms. Fine control is provided for the occupant of the room with an electric baseboard heater. There is a baseboard heater in each room automatically controlled via a room thermostat, set by the occupant.

Domestic Hot Water

The Motel is a large user of hot water. There are two heat exchangers in the fan room and the waste heat is normally adequate to bring the domestic hot water up to a satisfactory 38° C temperature. If extra heat is required, then the two 4.5 kW electric water heaters give the extra heat input.

The domestic hot water is circulated throughout the building in uninsulated copper pipes.

5.2 Restaurant Complex

This "complex", seen on Photograph P-1, is where most of the activities of the Inn take place. The original coffee shop is now a small portion of the building that now also includes a restaurant, cocktail lounge and craft shop.

From the outset, heating was provided with a forced air system. Propane was the fuel used initially but when the hot water became available, heating coils were installed into the return air inlet of the furnaces. The make-up air quantity could be large at times when the kitchen exhaust fan operates, thus drawing in cold outside air in the winter. The possibility of freezing was increased due to the fact that no glycol was in the system, but as the heating water was constantly in motion this never occurred.

The two new make-up air units that are now installed in the basement provide the heating for the building. The air is supplied using either floor grilles or ceiling diffusers and returned via a floor grille into the basement air plenum.

The units each have their own hot water coils. On each coil circuit (see Photograph P-10) a pump is connected into the supply pipe. This pump is purely there as a standby unit as the main system pump in the warehouse creates a large enough head to serve the coils itself, under normal circumstances.

It is in the basement of the restaurant that the link is made between the two culverts. On one side, a culvert goes below ground to the warehouse (see Photograph P-8). On the other side the hot water pipes enter the crawlspace before passing into the other culvert which travels underground to the Motel. So there is no position between the warehouse and the Motel where the pipes are inaccessible.

Domestic Hot Water

The Restaurant and Coffee Shop are large users of hot water. The hot water temperature should be at least 50° C, to adequately clean the kitchenware. As the "waste heat" hot water is often not this hot, the domestic hot water for the kitchen is provided totally by electric water heaters.

If electric water heaters were connected in series with a heat exhanger circuit, fed from the mains hot water, then a complicated controls system would be required. It would be necessary to ensure that 'reverse' heating did not occur, whereby the electric heaters are heating the circulating mains hot water.

5.3 Motel Office and Residence

The heating system of the office and residence has been renovated over the last couple of years, and now provides a very comfortable environment.

The hot water pipes, entering the motel basement, connect to a 900 litre surge tank (see Figure 4). Copper pipes are then taken from the tank, through the crawlspace and into the basement of the residence. The hot water pipes pass in series with an 82 kW propane-fired boiler. This boiler which used to be the prime heat source for the building, now acts as a standby in case of a leak in the distribution system, or breakdown of the main pump. The residence has its own pump, continually circulating the water to and from the surge tank in the motel.

The heating system is now an underfloor system. 15 mm polybutylene pipes were laid on the wooden floor and clamped down. Chicken wire also had to be laid across the floor and tacked down to keep the pipes flat. On top of the pipes was laid a 32 mm thick layer of lightweight concrete, followed by the floor finish.

One common complaint of underfloor heating systems is that the mass of the floor creates such a high thermal inertia, that control of the room temperature becomes ineffective and overheating on sunny days in winter is often a problem.

This particular system is split into 5 circuits, each 50 metres in length, and each with its own electric modulating control valve. These control valves are connected with thermostats strategically positioned throughout the residence and office.

Electric baseboards are also installed on the exterior walls but these are rarely required. The control of the system is excellent, the control valves modulating according to demand and due to the low inertia of the floor, overheating is rarely a problem.

5.4 Greenhouse

This building is partly considered a luxury but due to the fact that it is heated completely by the waste heat, it creates no expense. It creates an area for vegetable and flower growing and in fact a small commercial concern operates in the rear of the building, which is chinchilla breeding.

As is usually the case, this greenhouse has very poor insulating qualities and is therefore a very inefficient user of the heat input. In this case however, the large heat loss proves to be good for the system, in that it often saves the generator radiator fan from operating. The fan would be used when the hot water temperature got too high.

38 mm hot water pipes run underground from the warehouse to the greenhouse. The heating is an underfloor system and consists of 25 mm steel pipes laid at 450 mm centers within the gravel floor. Steel was used to offer better protection against damage. Two circulating pumps are installed, one acting as a standby with a flow switch control. These pumps are large enough to also circulate water up to the two residences, should their pumps fail.

There are two exhaust fan/coil units which discharge through opposing walls. These units operate automatically by means of an air temperature sensor. With the coils being in series with the underfloor heating system, the fans operate when the temperature in the greenhouse gets too high, and thereby cool the circulating hot water down. As a result the heat output of the underfloor system decreases. In the summer these fans are particularly useful as they help to dump the excess heat created from the generators.

5.5 Family Residences

These houses are remotely sited in a treed area at the north end of the site. One house was built in 1977 while the other was finished in 1982. Both of them have underfloor heating systems.

The hot water pipes that feed the two houses are taken off the greenhouse system. These 25 mm polyethylene pipes (see Photograph P-13) are insulated in fibreglass and a polythene wrap and laid on the ground. This was initially meant to be a temporary arrangement but it remains today and is still proving effective after six years. In the future it is proposed to install two 50 mm polybutylene pipes in a buried culvert, as done in other areas of the site.

The underground heating system is split into four circuits of 25 mm polyethylene pipe (see Photograph P-13). The piping is laid out in circles, spiralling out from the center of the floor. One circuit is used purely as a perimeter circuit to counteract the high heat loss here.

The distribution headers are positioned with the pump at the rear of the house, with no possibilities for damaging the polyethylene pipes. Only one pump was installed as the main system pump has sufficient head to circulate the water if the house pump failed.

The houses are also provided with electrical baseboard heaters. The underfloor heating maintains a temperature of 15° C with the fine control provided by the baseboard, automatically controlled themselves by thermostats.

One problem that occurs in the housing is a layer of frosting that builds up on the lower portion of the windows in winter. This is due to the lack of perimeter fin or warm air outlet underneath the window, which would normally counteract the cold down flow of air. A solution has been to lay a 150 mm wide styrofoam pad along the base of the windows, but an improved design shall be looked into for the next underfloor system.

6.0

COST SAVINGS ANALYSIS

6.0 COST SAVINGS ANALYSIS

We have decided to show some costs for the various portions of the project.

This project is unique and as such, comparisons or the use of some of the figures for savings, would be unfair to all parties and also could give quite misleading conclusions.

The reason it was decided to generate their own power at the Snowshoe Inn, was so that free heat would be available for all the buildings. The savings, resulting from the fact that the manager designed the whole system himself and devoted countless hours to the installation and maintenance, can never be fully realized.

Electrical Power

Under normal circumstances the complex would be split into six metered circuits. The following information was recorded:

> Over the period May-October 1981
> the total electricity usage at an
> average load of 63 kW was 275,940 kWh.
>
> Over the period November 1981-April 1982
> the total electricity usage at an
> average load of 88 kW was 385,440 kWh.

So if we can approximate the breakdown of the total kWh's and estimate the maximum kW loads of each of the separate systems, we can find a very approximate hypothetical cost of what the Motel would have been charged for its electricity.

	Winter (Max. kW)	Summer (Max. kW)	Winter (kWh)	Summer (kWh)
Warehouse/Research Building	10	10	21,840	21,840
Restaurant Complex	35	35	100,000	124,100
Motel	45	20	176,600	95,000
Office/Residence	10	5	31,000	15,000
Residence #1	10	5	28,000	10,000
Residence #2	10	5	28,000	10,000

The figures used for the following chart are as shown in the "Fort Providence" section of this report, except for the fuel clause adjustment rate which was 2.169¢/kWh at the time.

	Standing Charge ($)		Energy Cost ($)	
	Winter	Summer	Winter	Summer
Warehouse/Research Building	30.50	30.50	5,394	5,394
Restaurant Complex	106.75	106.75	24,651	30,589
Motel	137.25	61.00	43,525	23,420
Office/Residence	30.50	15.25	7,651	3,708
Residence #1	30.50	15.25	6,911	2,476
Residence #2	30.50	15.25	6,911	2,476
			95,043	68,063

The hypothetical total cost for electrical power during the period May 1981-April 1982 = $163,000.00.

Generator Oil Consumption

During the same annual period 1981-82 the total fuel (P40) consumption of the generators was 218,000 litres.

Over the same period the usage of lubricating engine oil was 818 litres.

At the time the costs of the fuel and oil were $0.27/litre and $1.00/litre respectively.

So the annual cost for fuel and oil in 1981-82 was $59,678.00.

Savings Analysis

In this particular project, there is no doubt that the savings from generating their own power, and using the waste heat for all the heating requirements, is substantial.

The power cost in 1981-82 would have been approximately $163,000.00 The cost of fuel for power and heating in 1981-82 was $59,678.00.

Of course this second cost of $59,678.00 does not include all the maintenance, modifications and all the other associated work that is performed "in-house" at the Snowshoe Inn. This cost would be significant if it had to be contracted out, especially if the labour had to be flown in.

On the other hand to the $163,000 cost should be added a cost for the fuel that would have been used for the heating systems required, if no waste heat had been available. This extra cost for the fuel would have been approximately $20,000.00 which can pay for alot of major repair work.

Initial Capital Costs of System

When the whole concept of "in-house" power generation was investigated, it was calculated that the installation would save $2,500/month in fuel bills. As it turned out, slightly more than this was saved and as the power and fuel prices increased, so did the savings.

The capital cost of the system including the two original generators, the overground polyethylene hot water distribution system and all the labour involved (except that of the Manager) was $50,000.00. The payback on this was less than two years.

7.0

RECOMMENDATIONS

7.0 RECOMMENDATIONS AND OBSERVATIONS

It would be difficult to make recommendations on this system, that has been gradually improved over the last 12 years through research, trial and error. The process of improvement is a continuous one and it is only time and finances that prevent some of the further necessary upgrading such as:

: Installing new underground culvert to the two residences.
: Providing new standby pump for main circulation system.
: Connection of hot water supply to the General Stores and possibly the Swimming Pool and so making the use of the waste heat even more efficient.

Observations for other similar projects are listed as follows:

1. There is no doubt that this project has been a huge success. The fact that the Motel Manager had such a strong background in the mechanical engineering field, meant that he was able to design and direct the complete installation of the generators and distribution system. He also devoted countless hours to maintenance and the many problems that crop up over the years.

   With this in mind, if that knowledge and dedication is available in a similar community, the option of a similar sized complex to generate its own power and use the waste heat for a number of buildings, is certainly worth the consideration.

   If the community generators are fairly central within the community, the possibility of using the waste heat from the engines should be studied first of all.

2. Underfloor Heating

   Most of the buildings of the Snowshoe Inn are now provided with underfloor heating. One reason for going in this direction, was that the low water temperatures from the engines, made an underfloor system one of the only practical choices. Having installed the motel system, the Manager was very impressed with the comfortable conditions created and went on to convert the other buildings to a similar system.

It was learned that the lower the thermal inertia of the floor, the better the control is within the heated space. Experiments are now in progress to use molded styrofoam panels to lay beneath the pipes and it certainly seems there could be a future for such systems in the North.

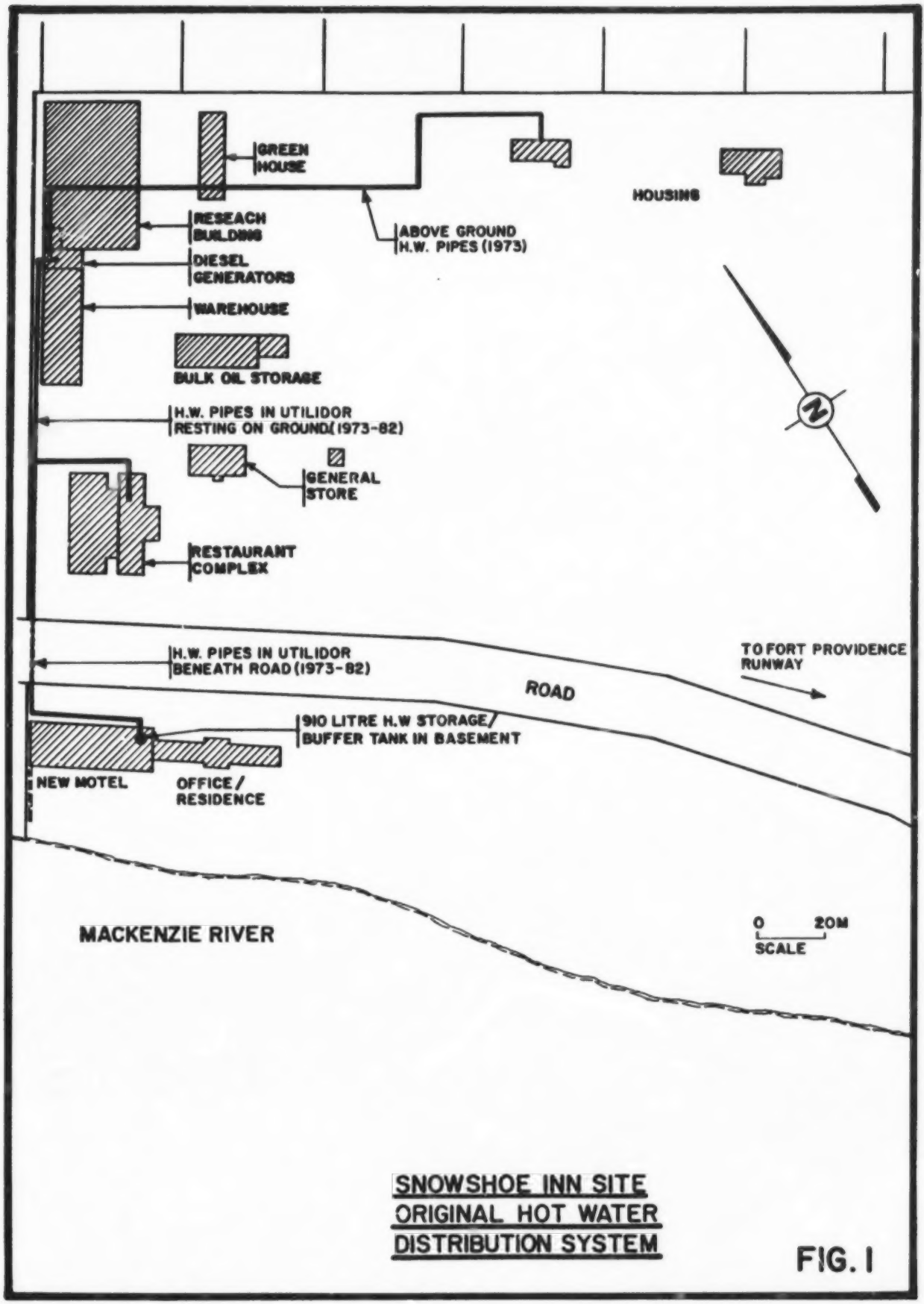
3. The underground culvert used to distribute the piping is an excellent idea for the North. Within the culvert can be run hot and cold water pipes, sewage pipes and even electrical cables. As the culvert is 1,000 mm in diameter, the piping is always accessible and if warm air is blown through, then no insulation is required on thaw stable soils.

4. Polybutylene Pipe

The use of this pipe as a hot water carrier is a new application in the North and its many qualities (detailed in the Appendix) make its use worth considering in future.

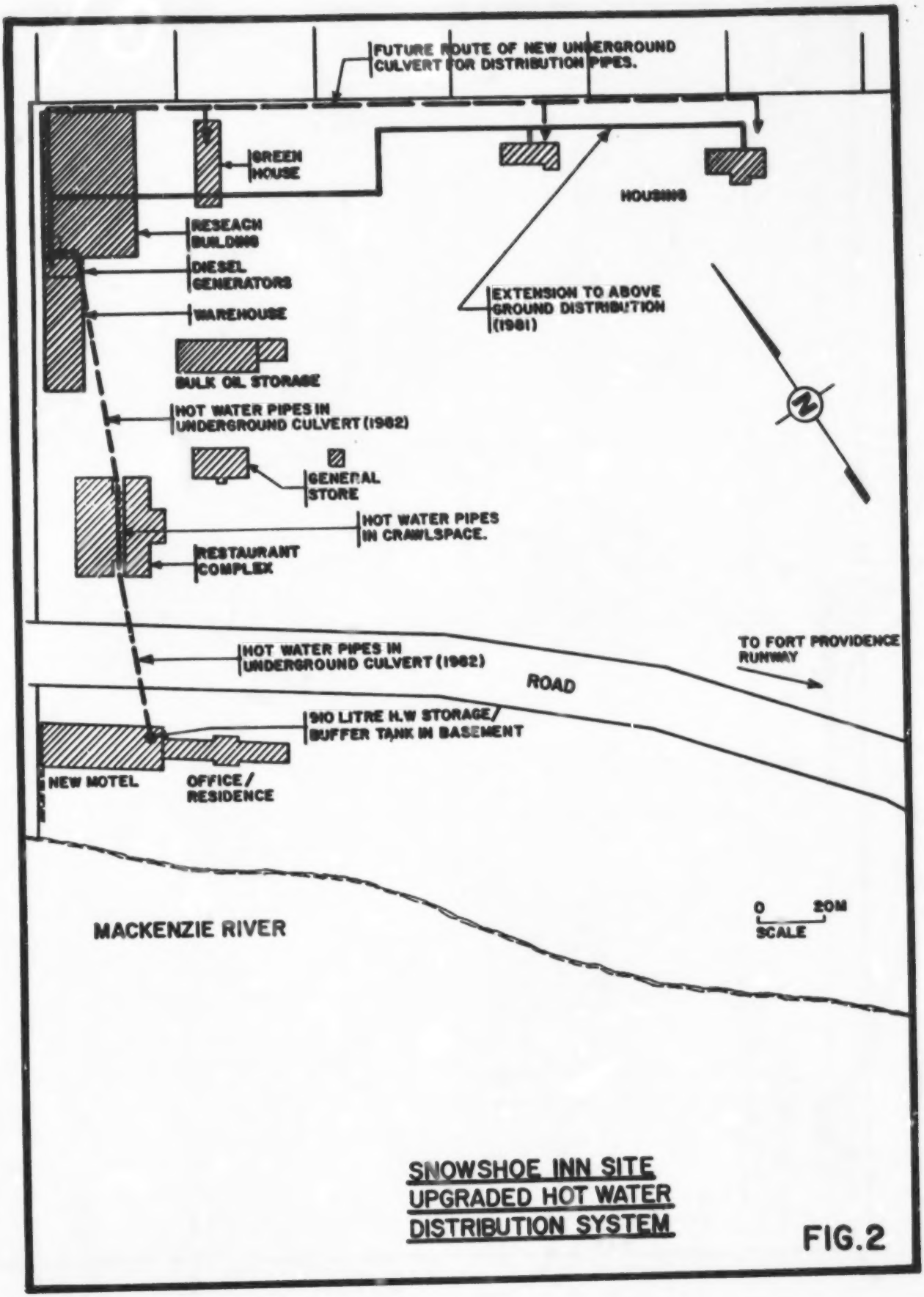
8.0

FIGURES



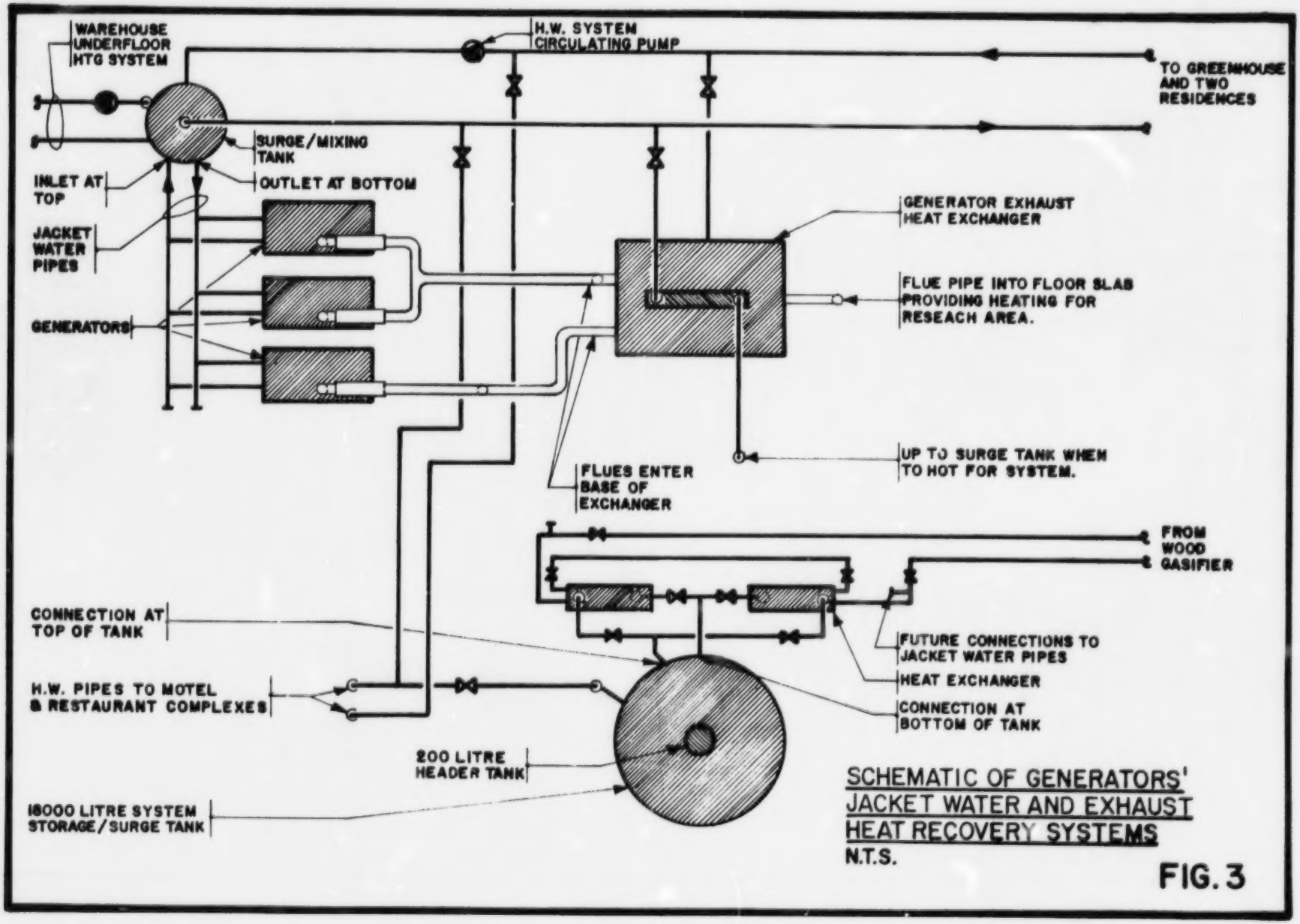
SNOWSHOE INN SITE
ORIGINAL HOT WATER
DISTRIBUTION SYSTEM

FIG. 1



SNOWSHOE INN SITE
UPGRADED HOT WATER
DISTRIBUTION SYSTEM

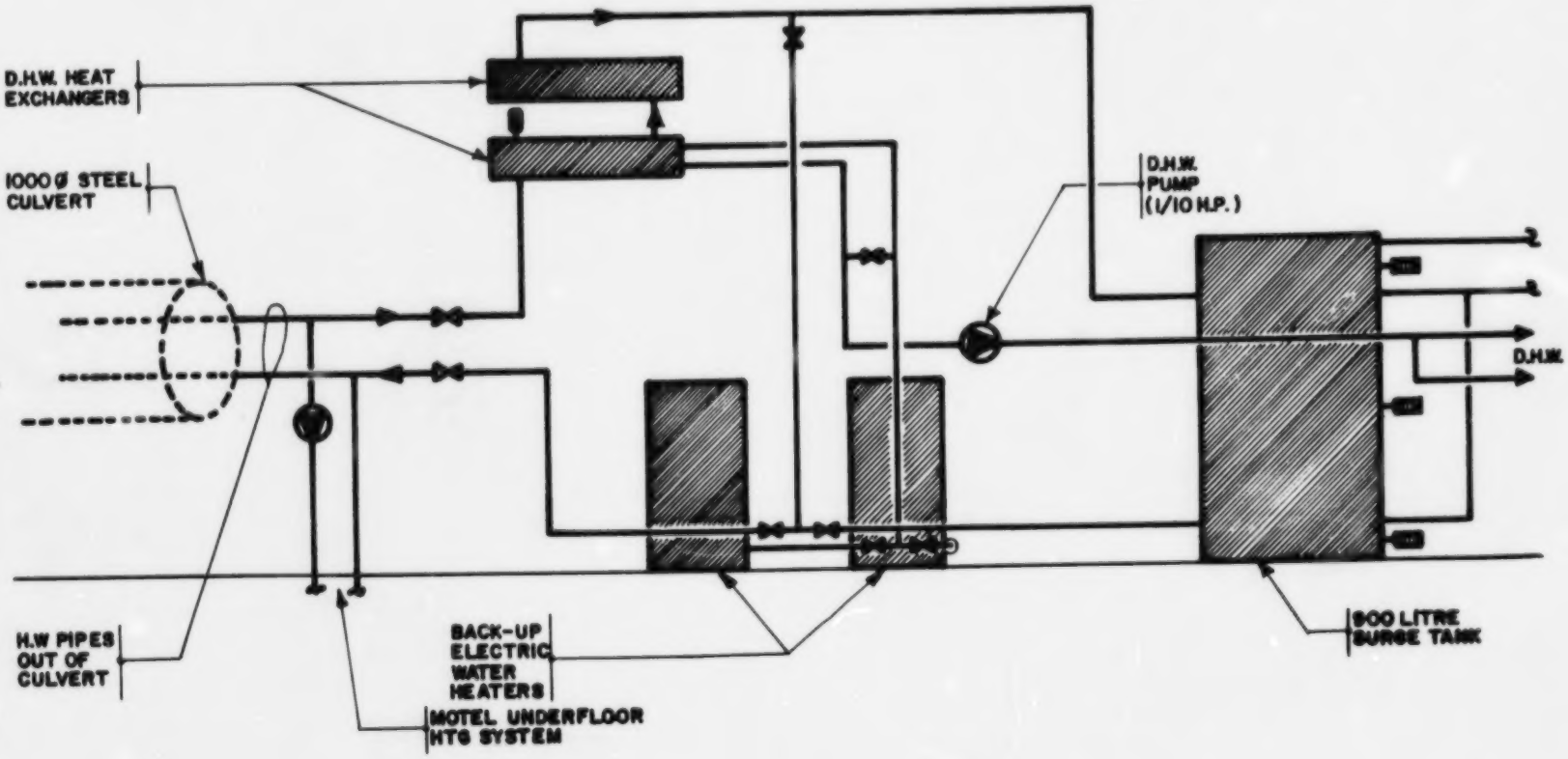
FIG.2


WAREHOUSE UNDERFLOOR HTG SYSTEM
H.W. SYSTEM CIRCULATING PUMP
TO GREENHOUSE AND TWO RESIDENCES
SURGE/MIXING TANK
INLET AT TOP
OUTLET AT BOTTOM
JACKET WATER PIPES
GENERATORS
GENERATOR EXHAUST HEAT EXCHANGER
FLUE PIPE INTO FLOOR SLAB PROVIDING HEATING FOR RESEACH AREA.
UP TO SURGE TANK WHEN TO HOT FOR SYSTEM.
FLUES ENTER BASE OF EXCHANGER
FROM WOOD GASIFIER
CONNECTION AT TOP OF TANK
FUTURE CONNECTIONS TO JACKET WATER PIPES
HEAT EXCHANGER
H.W. PIPES TO MOTEL & RESTAURANT COMPLEXES
CONNECTION AT BOTTOM OF TANK
200 LITRE HEADER TANK
18000 LITRE SYSTEM STORAGE/SURGE TANK

SCHEMATIC OF GENERATORS' JACKET WATER AND EXHAUST HEAT RECOVERY SYSTEMS

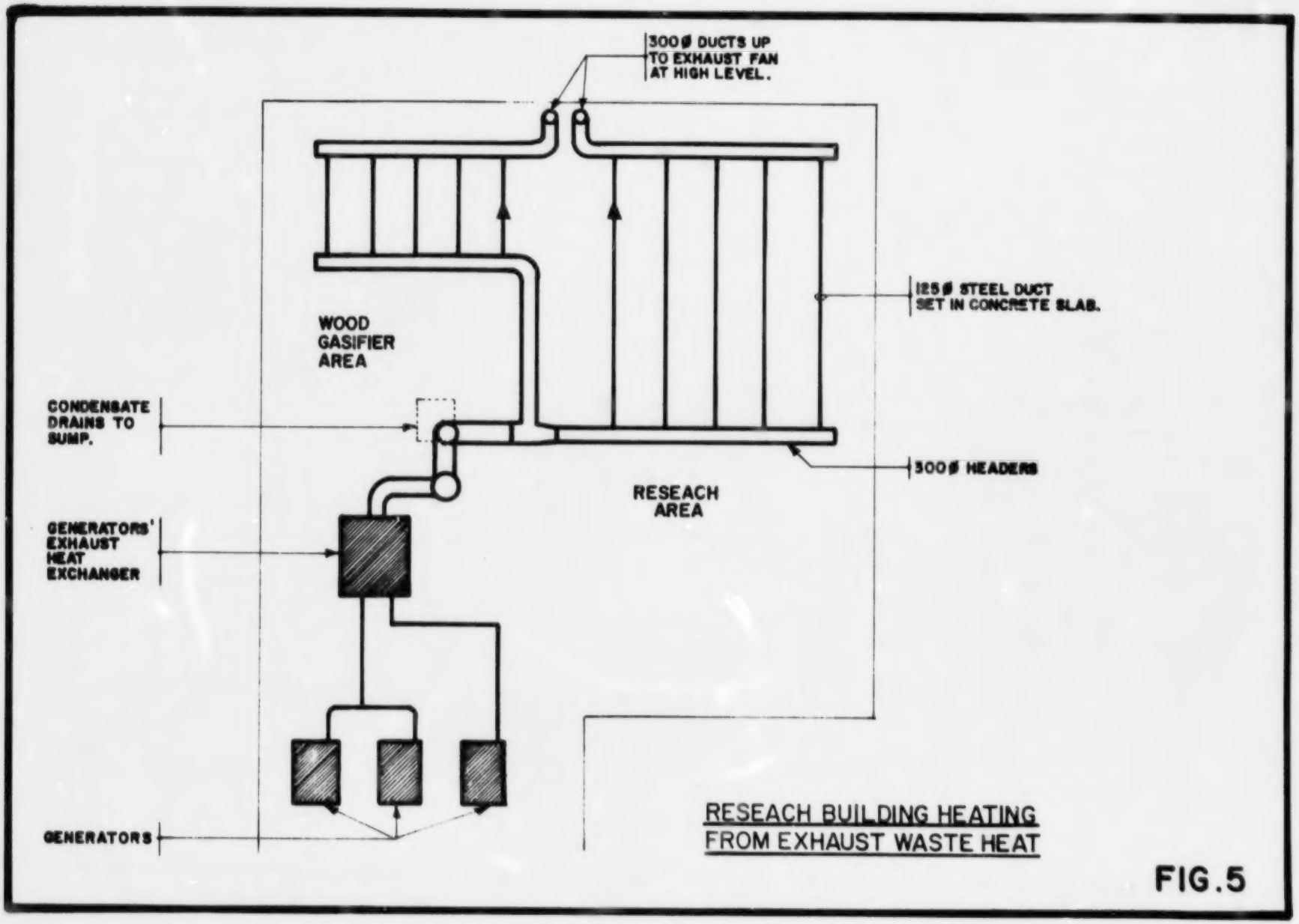
N.T.S.

FIG. 3



SCHEMATIC OF MOTEL DOMESTIC HOT WATER & UNDERFLOOR HEATING SYSTEMS

FIG. 4



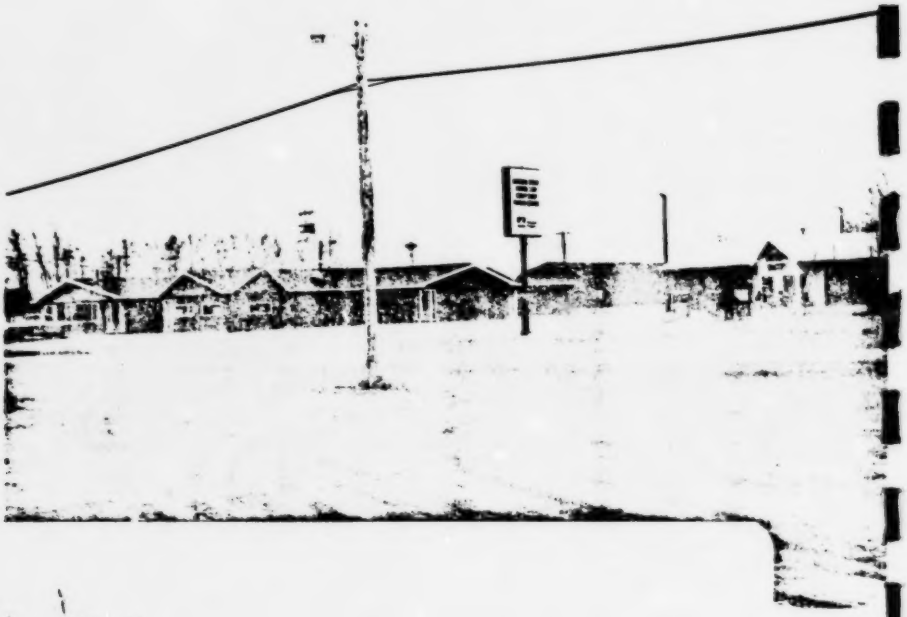
RESEACH BUILDING HEATING
FROM EXHAUST WASTE HEAT

FIG.5

9.0

PHOTOGRAPHS

SNOWSHOE INN
SITE LOOKING
FROM MOTEL

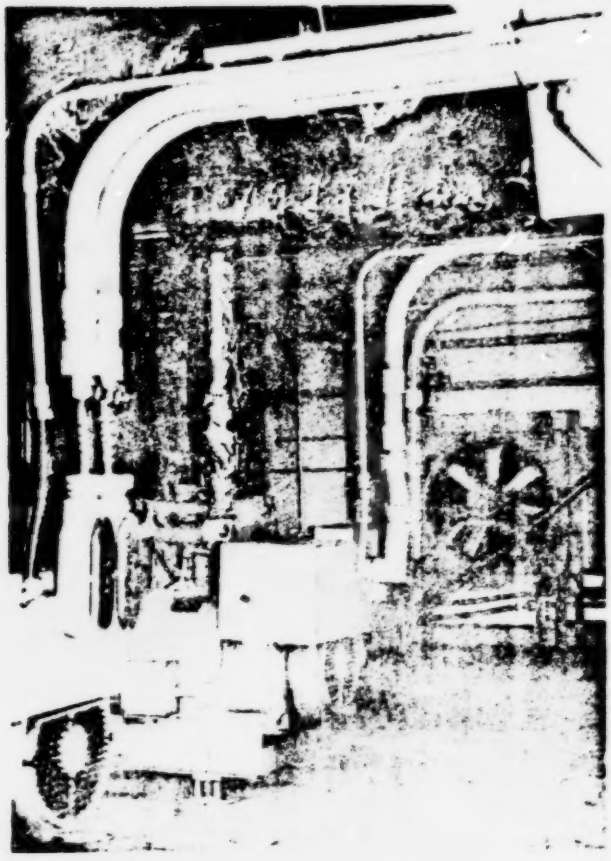


COFFEE SHOP/
RESTAURANT
COMPLEX

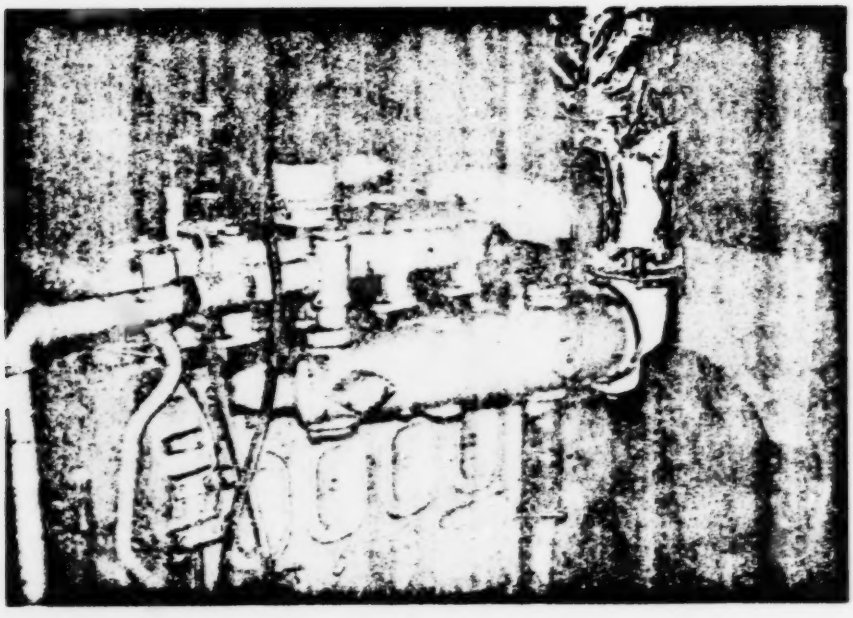
MOTEL & RESIDENCES

WAREHOUSE & RESEARCH BUILDING IN WHICH GENERATORS ARE LOCATED

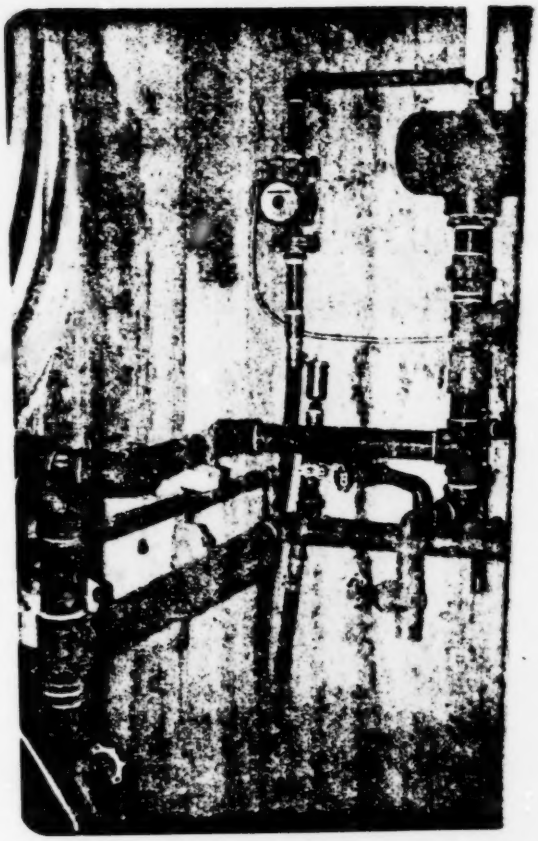
WASTE HEAT H.W. PIPES LEAVING WAREHOUSE



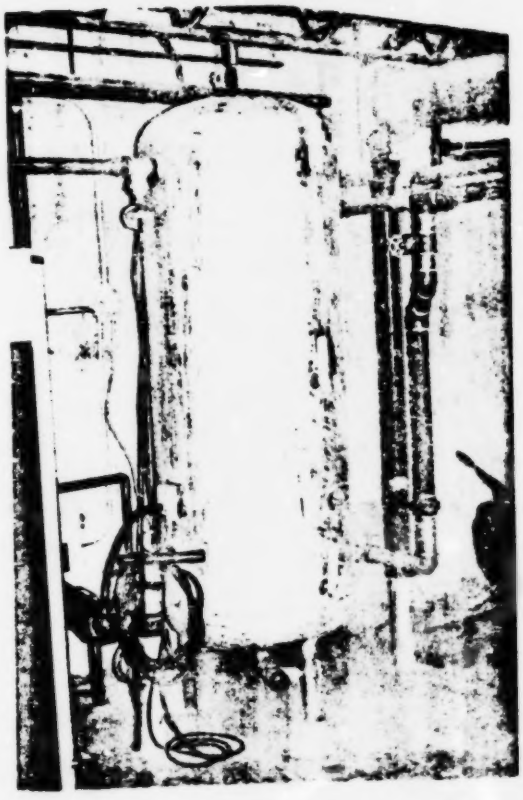
THE THREE ELECTRICAL GENERATORS IN WAREHOUSE



GENERATOR WATER-COOLED EXHAUST MANIFOLD.



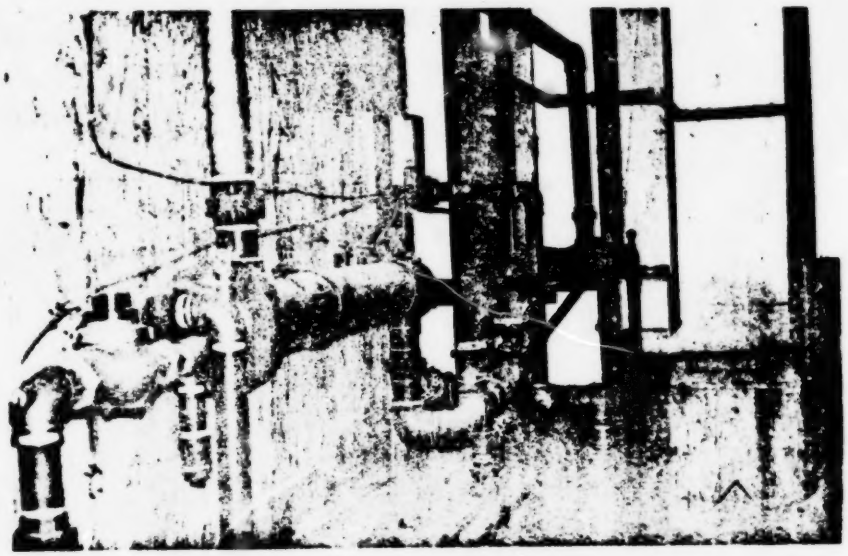
MOTEL UNDERFLOOR
H.W. SUPPLY PIPES



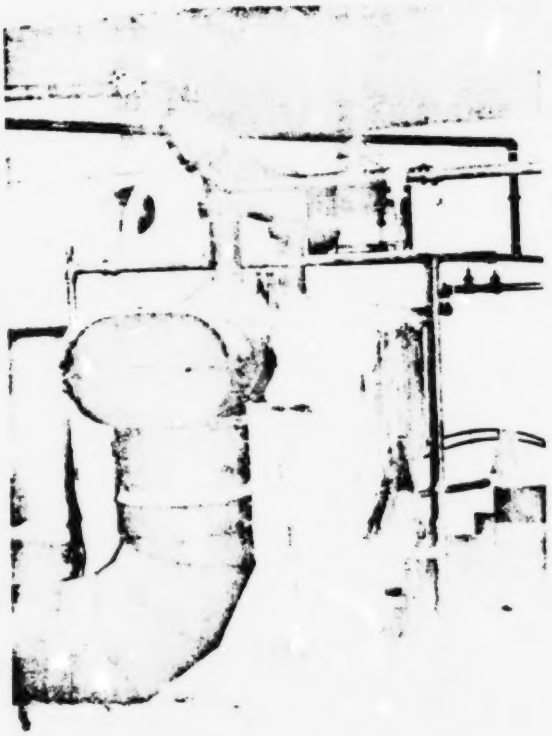
BUFFER/MIXING TANK IN
MOTEL MECHANICAL ROOM

GENERATOR JACKET WATER
BUFFER TANK.

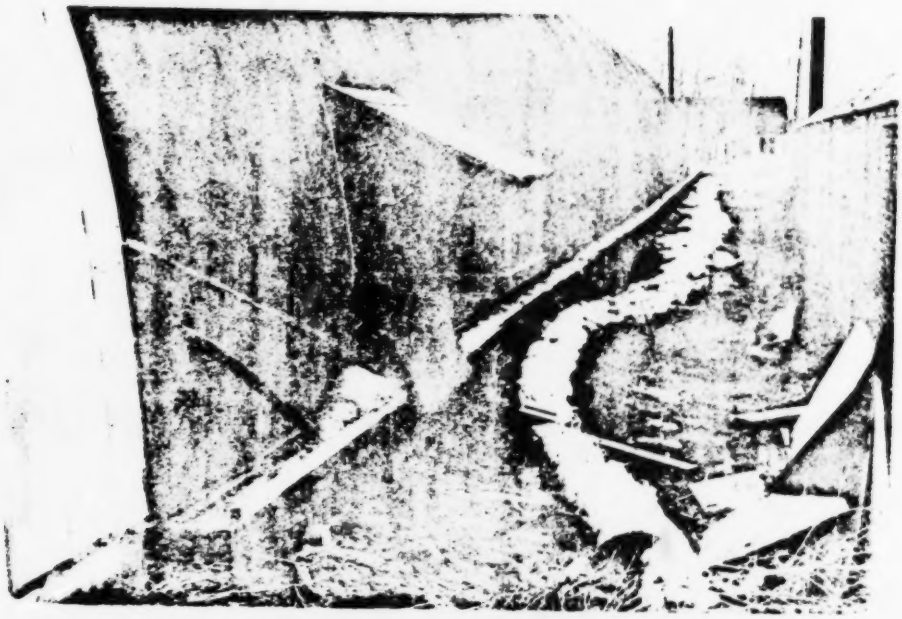
STORAGE/BUFFER TANK
NOTE: EXPANSION TANK ON
TOP PROVIDING SYSTEM
HEAD.



NEWLY INSTALLED JACKET WATER
HEAT EXCHANGERS.

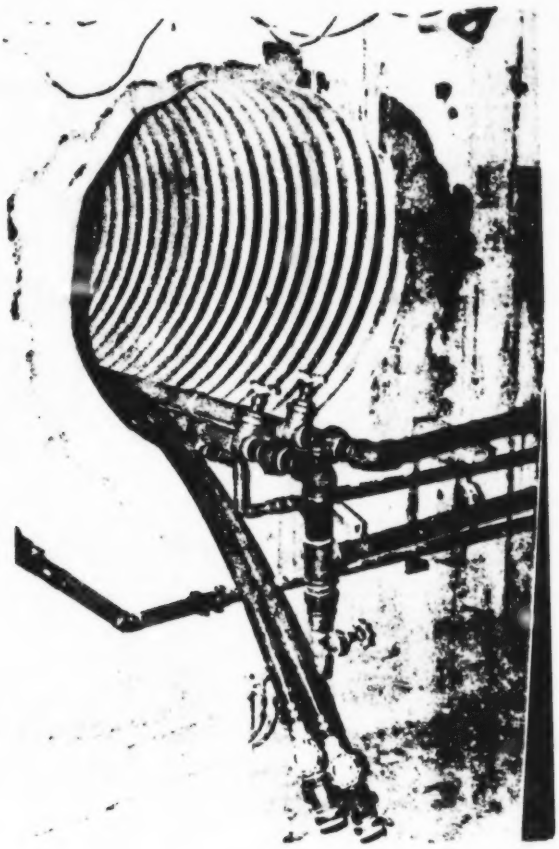


GENERATOR EXHAUST HEAT EXCHANGER.

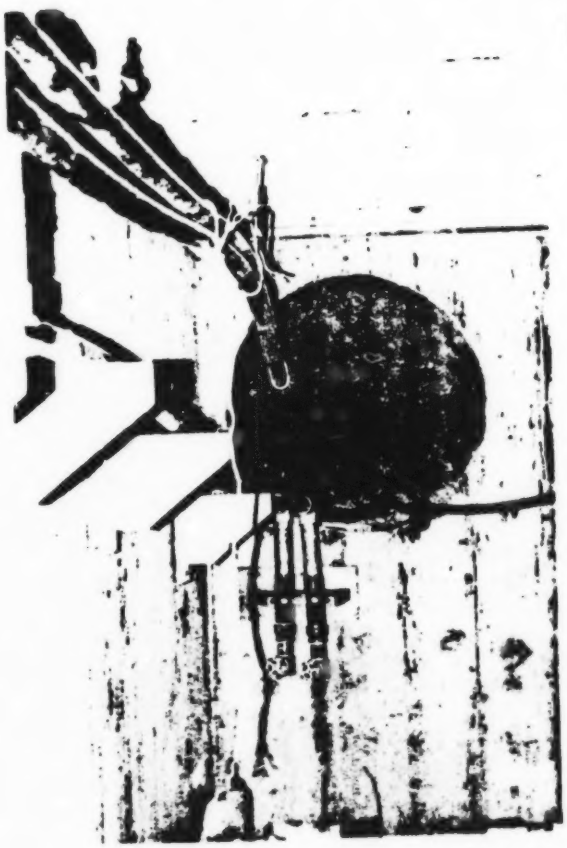


OLD DISTRIBUTION SYSTEMS
1. UTILIDOR
2. POLYTHENE WRAPPED INSULATED PIPEWORK

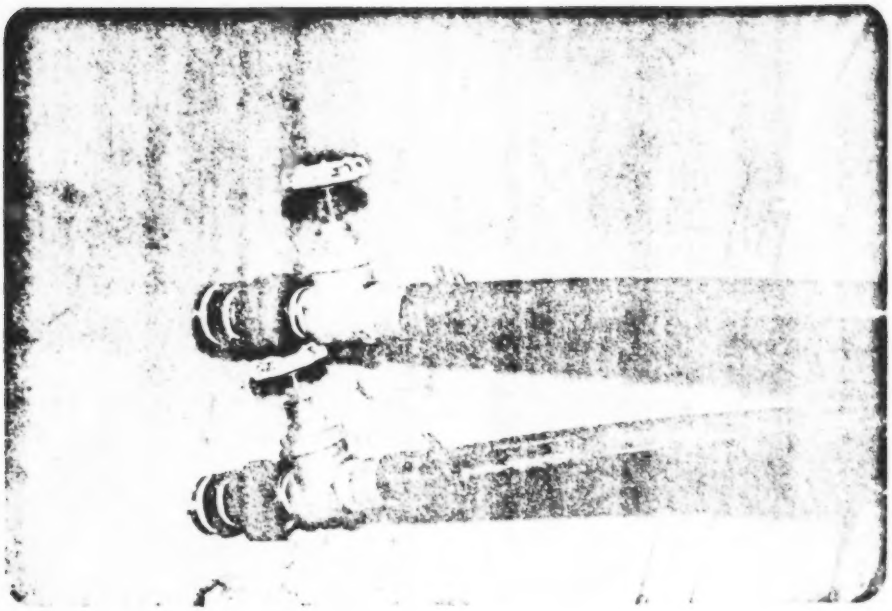
ORIGINAL UTILIDOR USED FOR H.W. DISTRIBUTION PIPES



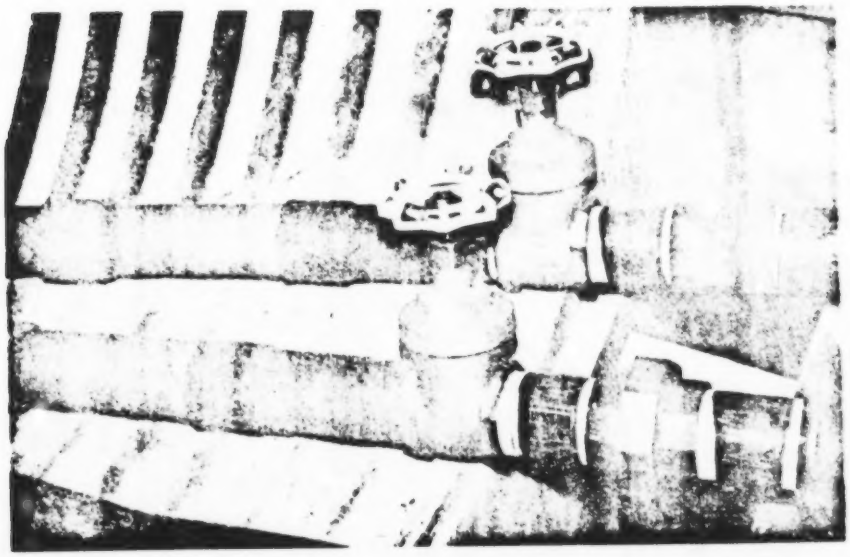
PIPES ENTER MOTEL
MECHANICAL ROOM.



PIPES ENTER RESTAURANT
MECHANICAL ROOM.

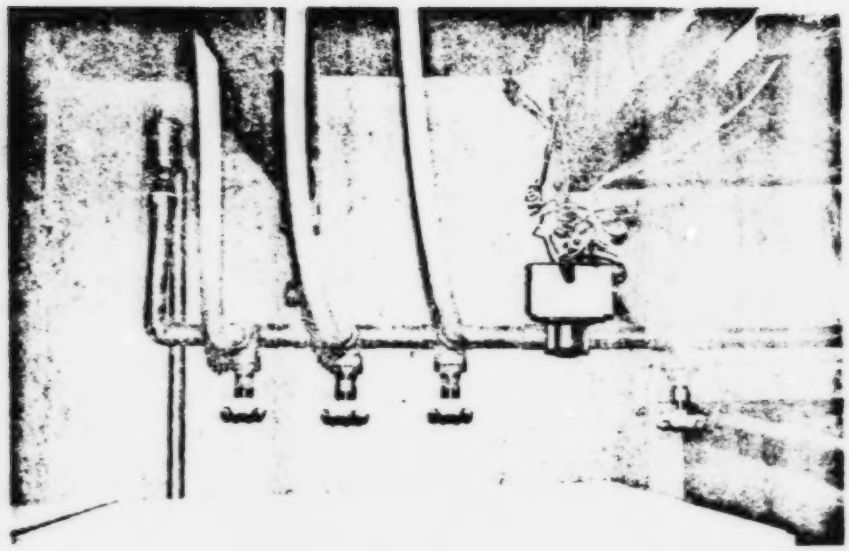


OLD 50mm POLYETHYLENE H.W.
DISTRIBUTION PIPES.



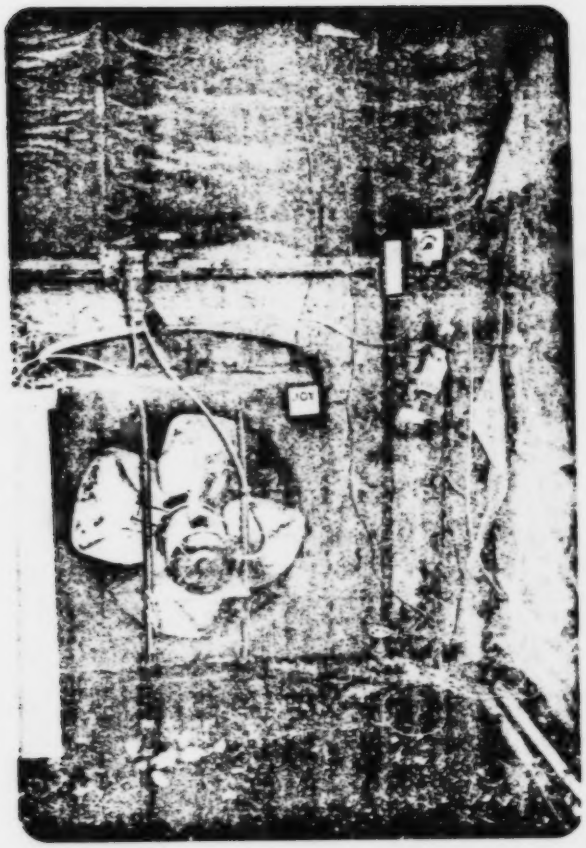
NEW 50mm POLYBUTYLENE H.W.
DISTRIBUTION PIPES.

RESTAURANT MAKE-UP AIR UNIT.

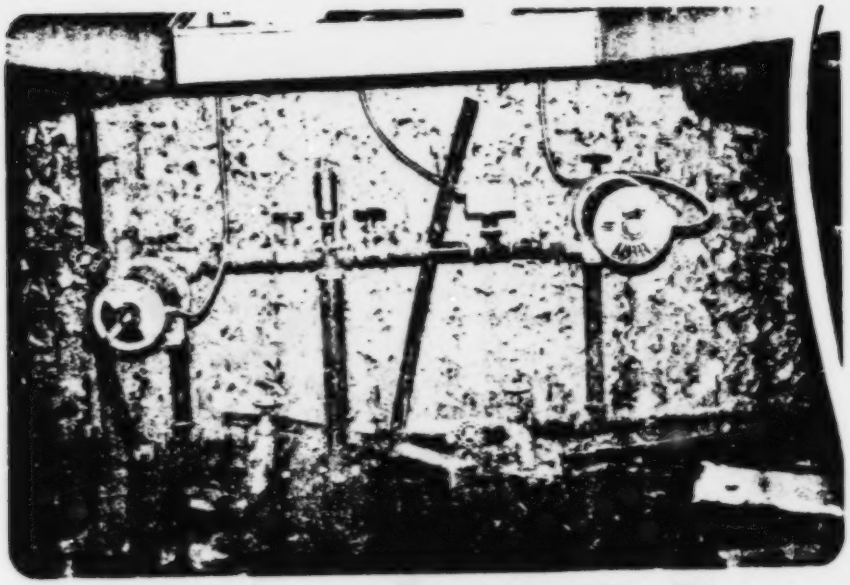


ONE OF ZONED DISTRIBUTION SUPPLIES

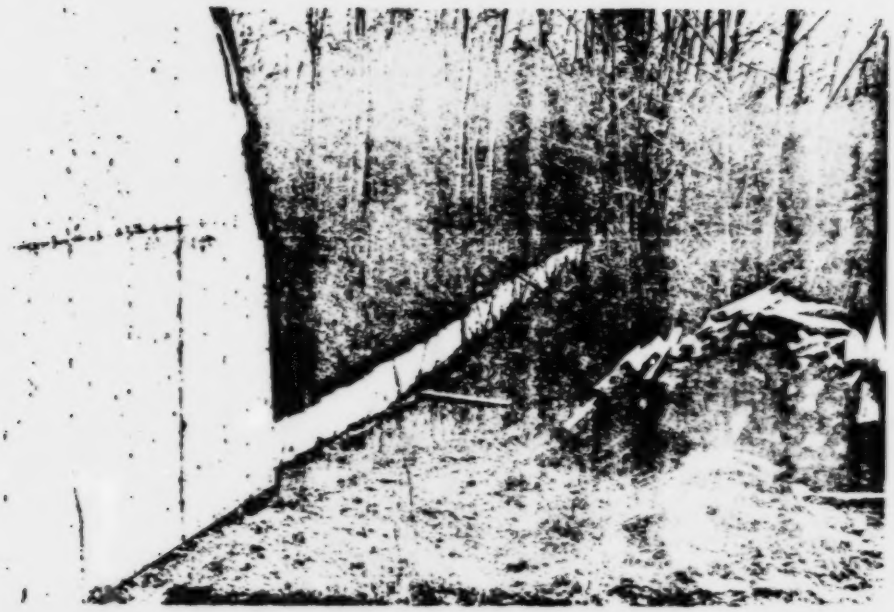
DISTRIBUTION RETURN PIPEWORK



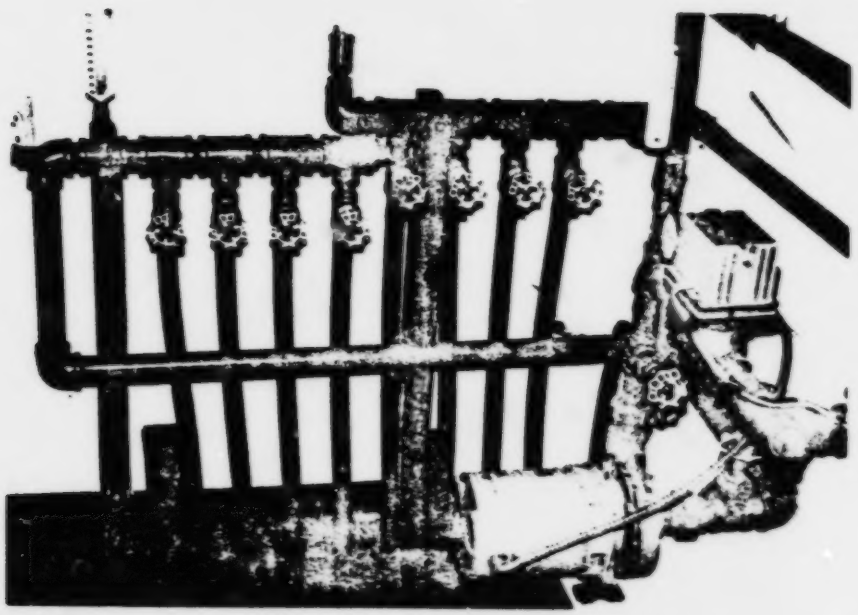
EXHAUST FAN/COIL UNIT FOR COOLING CIRCULATING WATER.



CIRCULATING PUMP WITH STANDBY ON FLOW-SWITCH CONTROL.



OVERGROUND DISTRIBUTION PIPES FROM GREENHOUSE TO HOUSING.



HOUSE UNDERFLOOR DISTRIBUTION HEATING HEADERS.

SWIMMING POOL

GROCERY STORE

POSSIBLE NEW MARKETS FOR WASTE HEAT

10.0

APPENDIX I:
POLYBUTYLENE PIPE

10.0 APPENDIX 1: POLYBUTYLENE PIPE

Polybutylene pipe is now used, wherever possible in any new system at the Snowshoe Inn. This is not typical of the North, or Canada as a whole, which has been resistant to changing to this type of pipe. It has however been very popular in Europe for many years. The application of using it for the main distribution pipes, showed it to be the ideal solution and it has worked very well in the underfloor systems. It's use as plumbing pipe has always been the advertiser's main selling point, but generally very little is known of the material by the general public.

We feel that there are suitable applications for it in the North and we have listed some of its specifications.

Chemical Resistance:	Excellent. Resistant to most aqueous salts, base and acids including some acids that rapidly corrode metals.
Stress Cracks:	Often seen in polyethylene and polypropylene pipes but polybutylene has never been observed to stress crack in any of the standard tests for this property.
Electrial Conductivity:	Very low. Good electrical insulator.
Fitting and Joining Methods.	1. Celcon: Most frequently used. Used to make both the barbed fittings. Becomes brittle in acid environments. 2. Copper and Brass: There are a number of fittings, infrequently used due to high cost. Often preferred where "Celcon" may embrittle. 3. Polybutylene: Fittings used in socket fusion method of joining. Often used in larger pipes where crimping requires pressures too high for manual application. Price competitive.
Flow Rates and Friction Losses:	Smooth internal surface and resistance to scale build-up give excellent flow characteristics.

Health and Safety:	Plastic pipe often blamed for rapid fire spread. Polybutylene should only be used where pipe contains water under pressure.
Hydraulic Shock:	Polybutylene pipe expands to reduce effect of water hammer.
Hydrostatic Design Stress and Maximum Temperature Limitations:	Pipe is suitable for continuous use at temperatures up to 200° F. The highest recommended pressure is 500 p.s.i. at 180° F.
Slab Heating:	The continuous lengths of pipe that is possible to lay provides a large saving in labour. Stress built up in slab by heating pipe is less than that for copper because the greater polybutylene expansion is offset by its lower elastic modulus (stiffness).
Weatherability:	If subject to ultra-violet light, pipe must contain carbon black to act as ultra-violet barrier.
Freezing:	Polybutylene pipe shall expand to accommodate frozen water and then regain its original shape completely. Pipe will not split at sub-freezing conditions.
Bending Radius:	Recommended minimum bending radius is 10X outside diameter of pipe.

11.0

APPENDIX 2:
REPORT DISTRIBUTION

11.0 APPENDIX 2: REPORT DISTRIBUTION

It is suggested that the distribution of this report should include the following:

i) Power Generating Utility Companies

Alberta Power Ltd., Edmonton, Alberta

Bowaker Power Co. Ltd., Deer Lake, Newfoundland

B.C. Hydro & Power Authority, Burnaby, B.C.

Calgary Power Ltd., Calgary, Alberta

Great Lakes Power Corp. Ltd., Saulte Ste. Marie, Ont.

Hydro-Quebec, Montreal, Quebec

Maine & New Brunswick Electric Power Co., Aroostock, N.B.

Manitoba Hydro, Winnipeg, Manitoba

Maritime Electric Co. Ltd., Charlottetown, P.E.I.

New Brunswick Electric Power Commission, Frederickton, N.B.

Newfoundland & Labrador Hydro, St. John's, Newfoundland

Nova Scotia Power Corp., Halifax, Nova Scotia

Northern Canada Power Commission, Edmonton, Alta.

Yukon Electric Co., Whitehorse, Yukon

Ontario Hydro, Toronto, Ontario

Ottawa Hydro, Ottawa, Ontario

Saskatchewan Power Corp., Regina, Saskatchewan

West Kootenay Power, Trail, B.C.

ii) Other Related Associations and Groups

Alberta Chamber of Resources, Edmonton, Alberta

Alberta Forestry Association, Edmonton, Alberta

B.C. & Yukon Chamber of Mines, Vancouver, B.C.

Canadian Electrical Association, Montreal, P. Q.

Council of Forest Industries, Vancouver, B.C.

Dept. of Forest Resources & Land, St. John's, Nfld.

Fisheries & Environment Canada, Downsview, Ont.

Forest Engineering Research Institute of Canada, Pointe Claire, P.Q.

Institute of Northern Studies, Saskatoon, Sask.

Manitoba Forestry Association, Winnipeg, Manitoba

Municipal & Community Affairs, Government of Yukon, Whitehorse, Yukon

N.W.T. Chamber of Mines, Yellowknife, N.W.T.

Nova Scotia Lands & Forest Association

Ontario Forest Industries Association, Toronto, Ont.

Ontario Forestry Association, Toronto, Ont.

Ontario Mining Association, Toronto, Ont.

Provincial Lands and Forests, Montreal, P.Q.

Provincial Planning Office, Dept. of Municipal Affairs and Housing, St. John's, Newfoundland

Quebec Asbestos Mining Association, Montreal, P.Q.

Quebec Metal Mining Association, Montreal, P.Q.

Saskatchewan Forestry Branch, Prince Albert, Sask.

Statistics Canada, Ottawa, Ontario

Town Planning & Lands, Dept. of Local Government, Government of the N.W.T., Yellowknife, N.W.T.